Will Doubling Urban Agriculture in the Twin Cities Improve Self-Reliance?

MS-STEP Professional Paper

In Partial Fulfillment of the Master of Science, Technology, & Environmental Policy Degree Requirements
The Hubert H. Humphrey School of Public Affairs
The University of Minnesota

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May 7, 2018

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Abstract

Urban agriculture is being promoted through city level policies to achieve goals in improving food security, increasing healthy food access, contributing to nutrition education, ensuring equity, and promoting economic development. Yet achieving these multiple goals through a single policy is complex and measurement of progress towards these multiple goals is even more difficult. This difficulty stems, in part, from a lack of information on the current size and distribution of existing urban farms.

Urban agriculture has been promoted for multiple objectives and as a strategy to meet those objectives in international, national, state, and city scale policies. These policies promote urban agriculture as a means for sustainability and self-reliance. Often these goals also promote equity. However, this promotion is ill-informed in terms of the current actual size and distribution of urban agriculture and therefore the ability to meet sustainability and self-reliance goals. This study seeks to describe the stated benefits of urban agriculture in urban food policies, define the current size and distribution of urban home and community gardens in the Twin Cities, and understand any differences in that size and distribution by income level.

Initially, I applied a virtual mapping method using Google Earth to scan census blocks for urban home gardens. However, this method was limited due to urban density with tall buildings, closely spaced residential plots, and a high concentration of trees and shadows. Therefore, I applied a transect method more suited to the Twin Cities area that involved field work to map urban home gardens. I selected census blocks spanning three income levels with alleyways and used an app called Fields Area Measure Pro to trace gardens found in the field, documenting the size and location. To map community gardens, I uploaded a map from city website that documented the location of community gardens. Then, I verified the garden location and traced the size while documenting the income level of the census block to collect the size and number of community gardens across income levels.

Ultimately, I found that the size and distribution of urban home gardens varied across income levels and that the number of community gardens varied by income level. I also found that the total area of urban gardening in the Twin Cities is estimated to currently contribute less than 0.5% to food demand. This information can serve to better inform current food policy by revealing the current actual contributions and the distribution of urban gardening across income levels.

1. Introduction

Global sustainability initiatives increasingly focus on urban areas because these areas are the source of many challenges facing the human population (Bettencourt & Ist, 2010). Urban locations currently hold over half of the world's population and this is predicted to increase to 66% by 2050 (UN, 2016). In addition to hosting most of the global population, urban areas generate 80% of the global gross domestic product (GDP) (World Bank, 2018). Consequently, urban areas are large contributors to global anthropogenic greenhouse gas (GHG) emissions, global water withdrawal and are also experiencing infrastructure and environmental-related mortality (Ramaswami, Russell, Culligan, Sharma, & Kumar, 2016). For example, an estimated 600 million (nearly 1 in every 10 people in the world) experience food-related illness and 420,000 die each year as a direct result of consuming contaminated food ("WHO | Food safety," 2017). Consumption of contaminated food is often due to lack of healthy food access and this inadequate access is tied to a lack of local food production (Opitz, Berges, Piorr, & Krikser, 2016; Treuhaft & Karpyn, 2010). Food crises in cities globally have been exacerbated by rapid urbanization presenting a lack of healthy food access and local food production, and therefore increases in food-related illness and mortality (Bettencourt & Ist, 2010). With the land area required to provide urban dwellers with food globally expanding, many cities have looked to urban agriculture for additional food production to assist in meeting city residents' food needs (Wigginton, Fahrenkamp-Uppenbrink, Wible, & Malakoff, 2018). Urban agriculture is particularly important because the expansion of urban areas often creates loss in agricultural land, displacing food production (Seto, Golden, Alberti, & Turner Ii, 2017). To support

urban food production as a means of food security and healthy food access, many cities have formed urban food policies (see Appendix 2).

The food supply sector is a large contributor to global sustainability impacts. Developed to improve global sustainability, the world's 17 Sustainable Development Goals (SDGs – listed on the right) framework seeks universal peace and freedom and to eradicate poverty. This framework was developed as a part of the United Nation's 2030 Agenda and is integrated and indivisible while balancing economic, social, and environmental frames. While the goals are presented as an integrated framework, it is helpful to reveal what specific goals are relevant to this study. Without disaggregating relevant goals, there is risk of missing incremental steps necessary to meet the goals. Alternatively, if I do not emphasize the holistic framework, there is risk of losing sight of the goals by neglecting to understand the interconnected nature of the framework. Therefore, the goals are listed here with several highlighted. The SDG framework includes 12 goals that either directly involve the food supply sector or are largely intertwined with food supply (shown in red), the connection between local food supply and these goals is illustrated in Appendix 1 (United Nations, 2017). Goal 2 calls for zero hunger globally and by ensuring food security and improved nutrition, with promoting urban agriculture as one way to achieve these goals. Investing in agriculture is described as a way to move toward reaching this goal because agricultural investments "alleviate poverty, improve food security and reduce hunger and malnutrition" (United Nations, 2017). This directly connects to the first goal to end poverty; investments in agriculture are mentioned as a way to reduce poverty and specifically investing in urban agriculture has been suggested to alleviate urban poverty (Zezza & Tasciotti, 2010). Even outside of the SDGs, global sustainability initiatives consistently mention food security and nutrition as a necessary part of future urban areas. For

Sustainable Development Goals:

1. No Poverty
2. Zero Hunger
3. Good Health and Ill-Being
4. Quality Education
5. Gender Equality
6. Clean Water and Sanitation
7. Affordable and Clean Energy
8. Decent Work and Economic Growth
9. Industry, Innovation and Infrastructure
10. Reduced Inequalities
11. Sustainable Cities and Communities
12. Responsible Consumption and Production
13. Climate Action
14. Life Below Water
15. Life on Land
16. Peace, Justice and Strong Institutions
17. Partnerships for the Goals

example, the New Urban Agenda was developed by the UN in response to SDG number 11 to make cities and human settlements inclusive, safe, resilient, and sustainable. The agenda establishes the need for equal access to food security and stronger food system planning (UN Habitat, 2017). This agenda calls for the integration of food security and nutritional needs of urban residents into urban planning – integrating food security and nutrition into urban planning cannot occur without a basic understanding of current urban agriculture in cities. Specifically the New Urban Agenda states that the support of urban agriculture and farming is an option to contribute to food security and nutrition (UN Habitat, 2017). Integrating food security and nutrition into urban planning requires a grasp of the size and distribution of urban agriculture to fully define the benefits achieved by these urban agriculture sites. Without an understanding of the current size and distribution of urban agriculture, policy is uninformed on how much urban agriculture is present and where urban agriculture is flourishing. This information further can inform any differences between income groups in current urban agriculture.

The Milan-Urban Food Policy Pact is another international initiative that expresses the need for urban areas to promote urban agriculture as a means to ensure food security and nutrition by locally providing food ("Milan Urban Food Policy Pact," 2015). With 163 signers, the Milan-Urban Food Policy Pact is evidence that cities are taking urban food production seriously. Out of these cities, 10 are from the United States and 9 of those have formed urban food policies. These US cities are shown in Appendix 2 among several other US cities that have formed urban food policies. The Milan-Urban Food Policy Pact is organized by six work streams including governance, sustainable diets and nutrition, social and economic equity, food production, food supply and distribution, and food waste (see Appendix 3 for full description of work streams). Selected descriptions of the food production work stream are included in Table 1 to show connections to urban agriculture. The work streams define where further action should be taken as "impact areas" which are shown in the second column in Table 1. The Milan-Food Policy Pact is further defined by recommended actions within the impact areas that seek to define what actions cities can take to achieve the impacts described within the food system. As Table 1 shows, the pact recommends that

cities promote urban agriculture to reach the overall goals of food security and nutrition. The parts of the pact shown in Table 1 are where the policy discusses producing food in the city within the food production work stream ("Milan Urban Food Policy Pact," 2015).

Table 1: Structure of the Milan-Urban Food Policy Pact relating to Urban Agriculture

Work Stream	Impact Areas	Recommended Actions
Food production	Urban and peri-urban food production and processing capacity is optimized and lessen dependence on distant food supply sources	Promote and strengthen urban and peri-urban food production and processing.
	Urban planners protect the local agricultural resource base and use in land use and city development plans	Protect and enable secure access and tenure to land for sustainable food production in urban and peri-urban areas. Apply an ecosystem approach to guide holistic and integrated land use planning and management.
	Producers have the required knowledge, skills and expertise	Help provide services to food producers in and around cities.

*The starred cities have signed on to the Milan-Urban Food Policy Pact.

Given that most of the world's population is living in urban areas, cities need to continue focusing on how to equally ensure food security. Local food production is one of the main avenues cities are considering to ensure equal food security.

Multiple objectives of urban food policies motivate sustainability initiatives searching to provide food in a sustainable, equitable manner. Many cities mention urban agriculture in different ways. City objectives of growing local food, increasing food security, or improving food access use urban agriculture as a strategy to meet those different objectives. Minneapolis states promoting and supporting a local food system as an objective with the strategies focusing on urban agriculture (Minneapolis, 2011). Austin uses urban food production as a strategy for increasing food security (Athens & Marty, 2016). Baltimore has an objective of increasing healthy food access and specifically mentions self-reliance through increased local production (Homegrown Baltimore, 2013). Included below in Table 2 are the objectives and

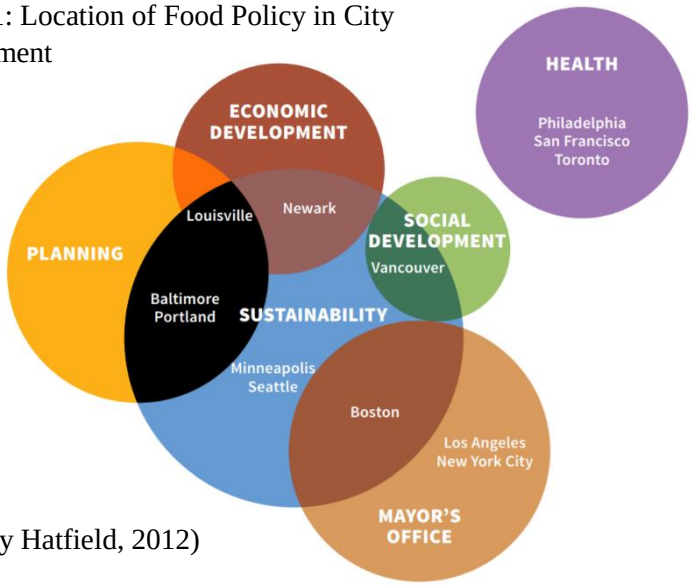
strategies that specifically mention urban agriculture; see Appendix 2 for a complete table of urban food policies and their multiple objectives and strategies.

Table 2: Urban Food Policy Plans with Urban Agriculture Objectives and Strategies

City	Policy	Objective	Strategy
Austin*	Austin Healthy Food Access Initiative	Increase food security	Increase urban food production
Baltimore*	Homegrown Baltimore: Grow Local	Increase healthy food access	Build community's food self-reliance through increased local food supply
Chicago*	Chicago Food Plan	Grow food	Support urban food production
Detroit	Creating a Food Secure Detroit	Access to quality food	Support urban agriculture
Minneapolis*	Urban Agriculture Policy Plan	Promote and support a local food system	Supporting and promoting community gardening, farmers' markets, commercial urban agriculture, and small enterprise or value-added agriculture in all city neighborhoods
New York City*	NYC Food Policy	Support a just and sustainable food system	Increase urban food production, improve education
Philadelphia	Philadelphia Food Policy Report	Urban agriculture	Procure land for urban agriculture, gather data on urban gardens
Pittsburgh*	Pittsburgh Food Policy Council	Urban agriculture	Procure land for urban growing
Portland	Portland Multnomah Food Policy Council	Urban agriculture	Promote community gardens and local food production through farmers' markets, market gardens, and food distribution points
San Francisco*	Food System Policy Program	Equitable, affordable, and accessible	Urban agriculture and land access
Seattle	Seattle Food Action Plan	Grow local	Promote urban agriculture
Washington DC*	DC Food Policy Council Report	Urban agriculture, food system education	Remove unnecessary regulations inhibiting urban agriculture

Additionally, the bureaucratic location of urban food policy in city government demonstrates the varying objectives and strategies within city-level food policy. This location is defined by what authority the food policy coordinator reports to (e.g. Mayor, Office of Sustainability, etc.) and how decisions are made. Figure 1 demonstrates this variety in a conceptual map that identifies where multiple food policies exist in city government structure. Hatfield, in her report on food policies, describes how policies housed in sustainability, health, social development, and mayoral offices, have all seen success, but the location largely influences the priorities of the food policy (Molly Hatfield, 2012). These varying priorities reflect how cities are considering urban agriculture differently and have come to consider urban agriculture as a strategy to meet a wide array of objectives. Common themes in city-level food policy objectives are food security, healthy food access, and equity in the food system. However, there is currently little evidence that urban agriculture can serve as a strategy for these objectives (Homegrown Baltimore, 2013; Santo, Palmer, & Kim, 2016; Taylor & Lovell, 2012). Further, the assumed benefits of urban agriculture are expressed with urban agriculture as an objective itself. When cities state urban agriculture as an objective they imply that urban agriculture provides certain benefits including food provision, security, and healthy food access. Homegrown Minneapolis is the organization that manages food policy in Minneapolis. This group was originally located in the Health Department in city government, but transitioned to the Office of Sustainability in 2012 (Molly Hatfield, 2012). Homegrown Minneapolis has priorities that reflect its current location in sustainability by prioritizing urban agriculture and its past location in the health department with a focus on healthy food access.

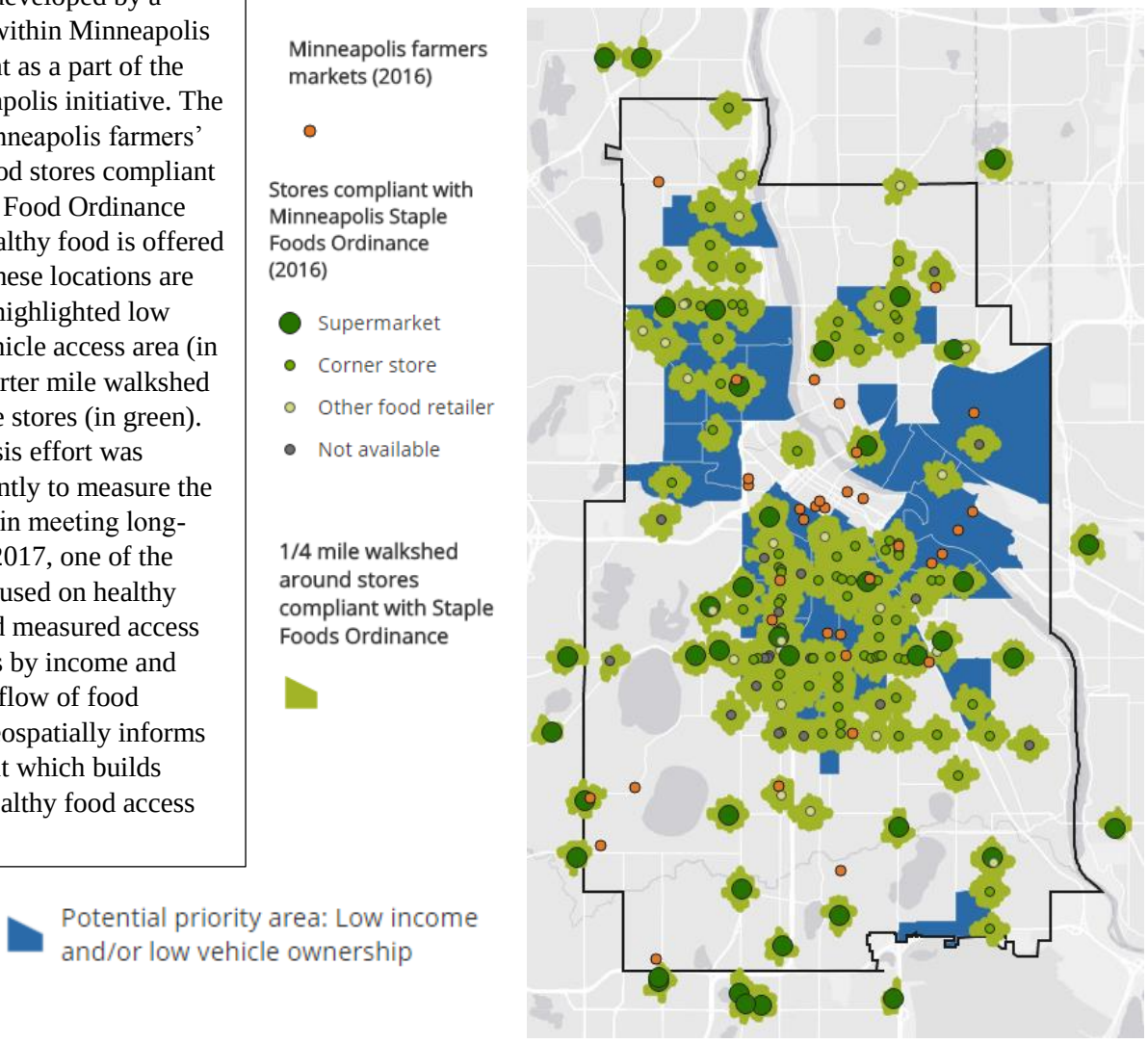
Figure 1: Location of Food Policy in City Government



(Molly Hatfield, 2012)

Figure 2: Minneapolis Healthy Food Access Map

This map was developed by a research team within Minneapolis city government as a part of the Results Minneapolis initiative. The map shows Minneapolis farmers' markets and food stores compliant with the Staple Food Ordinance that ensures healthy food is offered at the stores. These locations are informed by a highlighted low income and vehicle access area (in blue) and a quarter mile walkshed surrounding the stores (in green). The data analysis effort was developed recently to measure the city's progress in meeting long-term goals. In 2017, one of the reports was focused on healthy food access and measured access of food in areas by income and considered the flow of food dollars. This geospatially informs food investment which builds evidence for healthy food access policy.

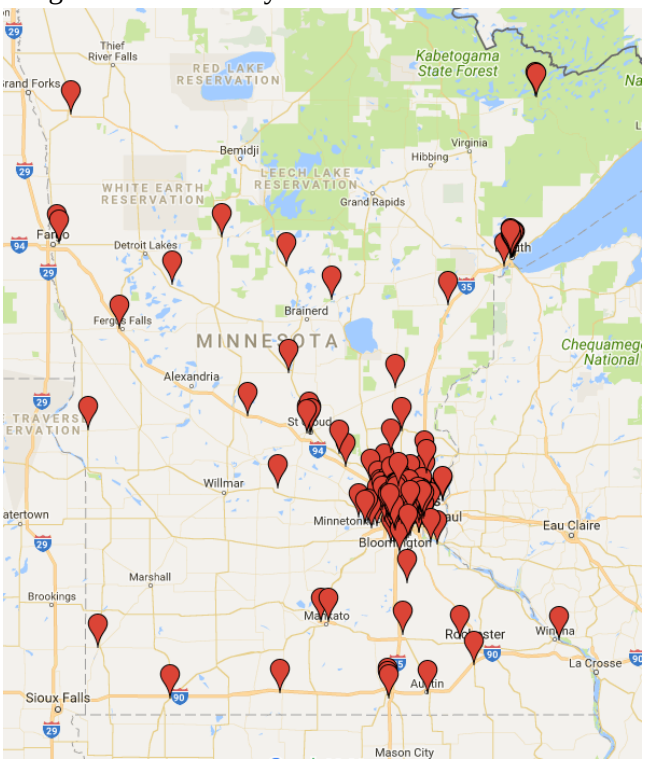


(Results Minneapolis & City of Minneapolis, 2017)

The healthy food access map highlights the idea of "food deserts" occurring within cities and difficulties vulnerable populations may have in accessing healthy food within these food deserts (Results Minneapolis & City of Minneapolis, 2017). The USDA tracts food deserts in the Food Access Research Atlas by census blocks nationally (USDA, 2015). The USDA defines these food deserts as areas that are both low income and low access. This definition also elaborates on ways to understand contributors to food deserts including income level, distance to supermarkets, and vehicle access. Food access is defined as limited access to supermarkets, supercenters, grocery stores, or other sources of healthy and affordable food that makes it difficult to consume a healthy diet (USDA, 2017). The criteria for low-income

neighborhoods is any census tract where: poverty rate is 20% or greater, median family income is less than or equal to 80% of the State-wide median family income, or within a metropolitan area and has a median family income less than or equal to 80% of the metropolitan's median family income (USDA, 2017). In the Twin Cities, the median family income is $70,915, so 80% of this is $56,732 (Bureau, 2016a). Using census data and American Community Survey data, the USDA maps out food deserts as defined by a combination of low-income and low access. Our study was motivated to consider the income levels of mapped census blocks to inform equity of garden distribution and size. This information can help determine if urban agriculture can play a role in minimizing constraints on aqcuiring healthy food that result in food deserts.

Figure 3: Community Gardens



Gardening Matters, 2018

In addition to the map of Healthy Food Access shown in Figure 2, Homegrown Minneapolis maps community gardens throughout the Twin Cities metro region and Minnesota through a partnership with Gardening Matters (Gardening Matters, 2018). Figure 3 shows the gardens located by Gardening Matters included on the Homegrown website. To compare the size and distribution of community gardens with our findings for home gardens, I verified that the gardens identified by Gardening Matters in Figure 3 were active using Google Earth and then mapped the area throughout the Twin Cities.

Many city-level policies, outlined in Appendix 2, discuss food security, nutrition, and healthy food access which all connect to the definition of food deserts. These policies often describe benefits from urban agriculture to ameliorate these issues in their objectives. Benefits cited in city-level food policy include improving food security, increasing healthy food access, contributing to nutrition education,

ensuring equity, and promoting economic development. These benefits are shown in Table 3 with the urban food policy that includes the benefits and connecting evidence from literature. These benefits also could contribute to city-level self-reliance.

Table 3: Stated Benefits of Urban Agriculture Compared to Literature

Stated Benefits	Urban Food Policy	Evidence in Literature	Citation
Improving food security	(Athens & Marty, 2016; City of New York, 2017; Philadelphia Food Policy Council, 2017)	Study in New York says urban agriculture contributes to food security by donating food to food banks and feeding communities. A survey in Portland found that low income households rely on their gardens for food security	(Ackerman, 2012; McClintock, Mahmoudi, Simpson, & Santos, 2016)
Increasing healthy food access	(Arellano Stephen & Kuras Amy, 2017; Athens & Marty, 2016; City of New York, 2017; City of Portland & Multnomah County, 2011; District of Columbia Food Policy Council, 2017; Homegrown Baltimore, 2013; Lerman, 2012; Maskin, Senior, & Planner, 2014; New Orleans Food Policy Council, 2017; Philadelphia Food Policy Council, 2017; Pittsburgh Food Policy Council, 2017),	Same New York study states that urban agriculture has the capacity to increase healthy food access.	(Ackerman, 2012)
Contributing to nutrition education	(Arellano Stephen & Kuras Amy, 2017; Athens & Marty, 2016; District of Columbia Food Policy Council, 2017; Homegrown Baltimore, 2013; Maskin et al., 2014; New Orleans Food Policy Council, 2017)	Gardening as outdoor science education in LA increased science skills, Texas schools with gardens showed higher standardized science test scores, Minneapolis – St. Paul study found youth in garden programs more willing to eat nutritious and unfamiliar foods and to cook than youth uninvolved in garden program.	(Blair, n.d.; Lautenschlager & Smith, 2007; Mccarty, n.d.)
Ensuring equity	(City of Portland & Multnomah County, 2011; District of Columbia Food Policy Council, 2017; Maskin et al., 2014; Pittsburgh Food Policy Council, 2017; Sokolove & Chen, 2014)	Multiple studies say that equity has been ignored in current urban agriculture initiatives including in Portland and Detroit.	(McClintock et al., 2016; Meerow & NeIll, 2017)
Promoting economic development	(District of Columbia Food Policy Council, 2017; Homegrown Baltimore, 2013; Lerman, 2012; Maskin et al., 2014; Minneapolis, 2011; Philadelphia Food Policy Council, 2017; Pittsburgh Food Policy Council, 2017; Sokolove & Chen, 2014)	Positive effect on housing prices, positive effect on property values in low income neighborhoods in New York, attract small businesses	(Conway, Li, Wolch, Kahle, & Jerrett, n.d.; Sherer, n.d.; Voicu & Been, 2008)

Coalitions of cities like the Cities of Service and the National League of Cities (NLC) advise cities on various policy initiatives and reference urban agriculture (Cities of Service, 2018; Hendrickson & Porth, 2012). Cities of Service outlines an agriculture education program using urban gardens to teach primarily children from low income families about nutrition and healthy cooking. The report outlines necessary elements including targeting specific low income locations, gathering community support and partnerships, engaging volunteers, and tracking and reporting metrics (Cities of Service, 2018). This touches on many of the objectives listed in city policies for urban agriculture including: food security, healthy food access, nutrition education, and ensuring equity. The NLC is more specific in a detailed report on Best Practices and Possibilities in Urban Agriculture. This report surveyed main players in urban agriculture policy, identified the most common questions, and then did the same for players in the urban agriculture community and matched up where policy could address barriers for current actors. The report contained several main takeaways encouraging cities to structure city ordinances and zoning to remove barriers for urban agriculture; support urban agriculture players for access to water, capital, and land; and to form food policy councils to keep citizens engaged (Hendrickson & Porth, 2012).

While the rise of urban food policies is recent, food policy has a long history at other levels of government. The National Conference of State Legislatures summarizes urban agriculture state legislation and describes the states roles mostly as assisting with funding urban agriculture in cities (National Conference of State Legislatures, 2018). A report delineating "Urban Agriculture in Minnesota" addressed to the state legislature explains what urban agriculture is and describes the state's role in urban agriculture policy. The report illustrates the state's role as supporting urban agriculture through accessible zoning policies and funding (National Conference of State Legislatures, 2018). The report further describes urban agriculture as included in the Thrive MSP 2040 Metropolitan Council Strategic Plan. Overall, the report summarizes many of the same benefits stated in city-level and international policies and then concludes that cities or counties are responsible for the bulk of urban agriculture policy-making. Nationally, urban agriculture is discussed primarily by providing resources to those engaged in urban

agriculture activities. Specifically, the USDA published an Urban Agriculture Toolkit that describes resources developed by urban farmers, federal and city governments, and local organizations to address challenges in urban agriculture (USDA, 2016). Therefore, while federal and state governments are interested in providing resources to urban agriculture participants, international policy has primarily set the agenda for cities when it comes to forming urban food policies and cities are responsible for policy formation and implementation.

Local food provision as creating self-reliance is connected to supplying basic needs including food, energy, water, and materials within a chosen set of boundaries. Generally, local self-reliance means providing basic necessities within the physical footprint of a locality (Morris, 1987). This goal seeks to provide food, energy, water, and materials in the most sustainable way through holistic planning that generates local autonomy and benefits the local economy. Related to self-reliance in food, (Grewal & Grewal, 2012) discuss the need to produce food in urban areas to achieve this self-reliance. Urban agriculture, including urban community gardens and home gardens, has gained attention as a means to accomplish the goal of producing food in urban areas

In summary, many city-level policies seek to promote urban agriculture because of its presumed ecosystem service benefits that include: food provision and self-reliance (De Bon, Parrot, & Moustier, 2010; Grewal & Grewal, 2012), carbon storage (Davies et al., 2011), water storage (Hankard, Reid, Schaefer, & Vang, 2016), increased biodiversity in the city (Goddard, Dougill, & Benton, 2010; Strohbach, Lerman, & Warren, 2013), equity and food security (De Bon et al., 2010; Poulsen, McNab, Clayton, & Neff, 2015; Santo et al., 2016; Zezza & Tasciotti, 2010), and human health and wellbeing contributions including: stress relief, recreation and improved overall health (Cameron et al., 2012; Kortright & Wakefield, 2011; Lovell & Taylor, 2013; Tzoulas et al., 2007). These benefits are yet unquantified and often vary by the size and distribution of the urban agriculture sites. This size and distribution is further unquantified in most locations, but this study contributes the size and distribution for the Twin Cities area which could allow for a greater understanding of ecosystem service benefits.

Furthermore, the uncertainty in stated ecosystem service benefits is mirrored by the uncertainty in urban food policy state benefits highlighted in Table 3. Some cities emphasize that backyard gardening is an unknown component of their urban food production (Homegrown Baltimore, 2013). Currently, there is not much quantitative information on the actual extent of urban agriculture in cities. For example, the USDA census reports commercial food production but does not address household backyard gardens and community gardens (forms of urban food production shown in Figure 4). Some studies suggest backyard gardening and community gardening could be a large contribution (Taylor & Lovell, 2012). A recent literature review covering the benefits and limitations of urban agriculture states that urban home gardens are under-represented in the literature, but that their "potential social, ecological, health, and economic contributions" could be significant (Santo et al., 2016).

Figure 4: Local Food System Production Typologies

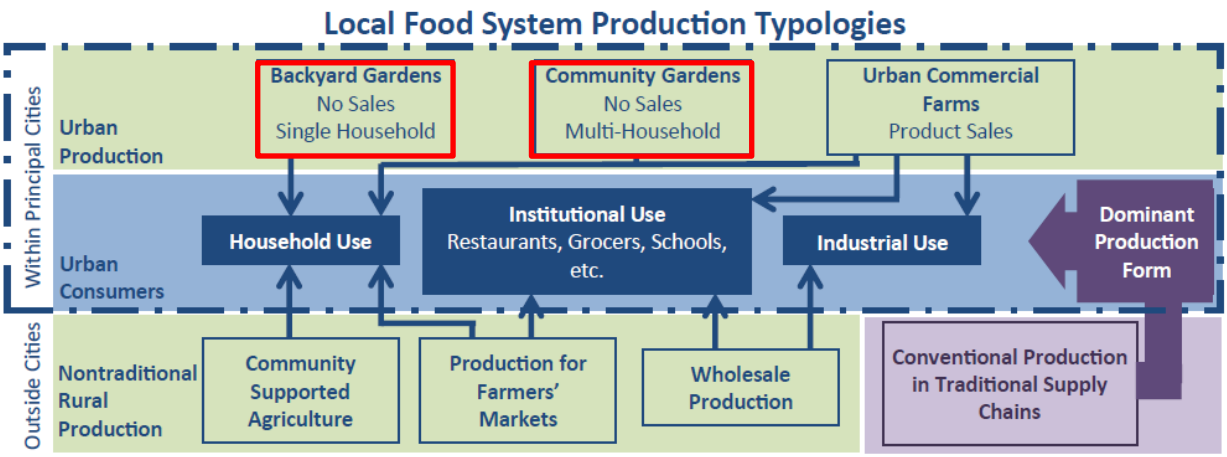


Figure 4 shows the local food system production typologies with the forms of production mapped in our study highlighted in red (Ambrose, Gurke, Nixon, & Ramaswami, 2017).

Given this knowledge gap, this study seeks to quantify the current contributions of urban gardening to self-reliance in the Twin Cities by defining the size and distribution of gardening and comparing backyard gardening with estimated food production.

1.1 Previous Studies

Very few studies have measured backyard gardening. Several studies have assessed the potential of urban agriculture in cities (Ackerman et al., 2012; Colasanti & Hamm, 2010; Grewal & Grewal, 2012; Kremer & DeLiberty, 2011; Parece, Serrano, & Campbell, 2017), but many of these studies did not include small-scale residential home gardens, though they mentioned that these gardens could be significant contributors to food supply (Ackerman et al., 2012; Colasanti & Hamm, 2010; Kremer & DeLiberty, 2011). Assessing the potential leaves a knowledge gap in the current actual urban gardening. Other studies have mapped current urban gardening using virtual method (Pulighe & Lupia, 2016; Taylor & Lovell, 2012; Foster and NeIll, in preparation). This virtual method was limited when applied to the Twin Cities area due to urban density.

1.2 Objectives

- Develop an improved method to map the size and spatial distribution of household backyard gardens and community gardens.
- Measure the size and distribution of gardens across income levels to inform equity, gather data to scale up, and inform ecosystem service benefits.
- Use data to scale up results to inform local reliance. I seek to compare mapped urban gardening with local household food consumption and to discuss contributions to self-reliance

This paper seeks to move toward understanding these benefits by mapping urban gardens throughout the Twin Cities to provide an assessment of contributions to self-reliance. Research has defined potential contributions of urban agriculture, but not current actual contributions of urban agriculture (Ackerman et al., 2012; Colasanti & Hamm, 2010; Grewal & Grewal, 2012; Kremer & DeLiberty, 2011; Parece et al., 2017).

Figure 5: Conceptual Diagram of Mapping and Analysis

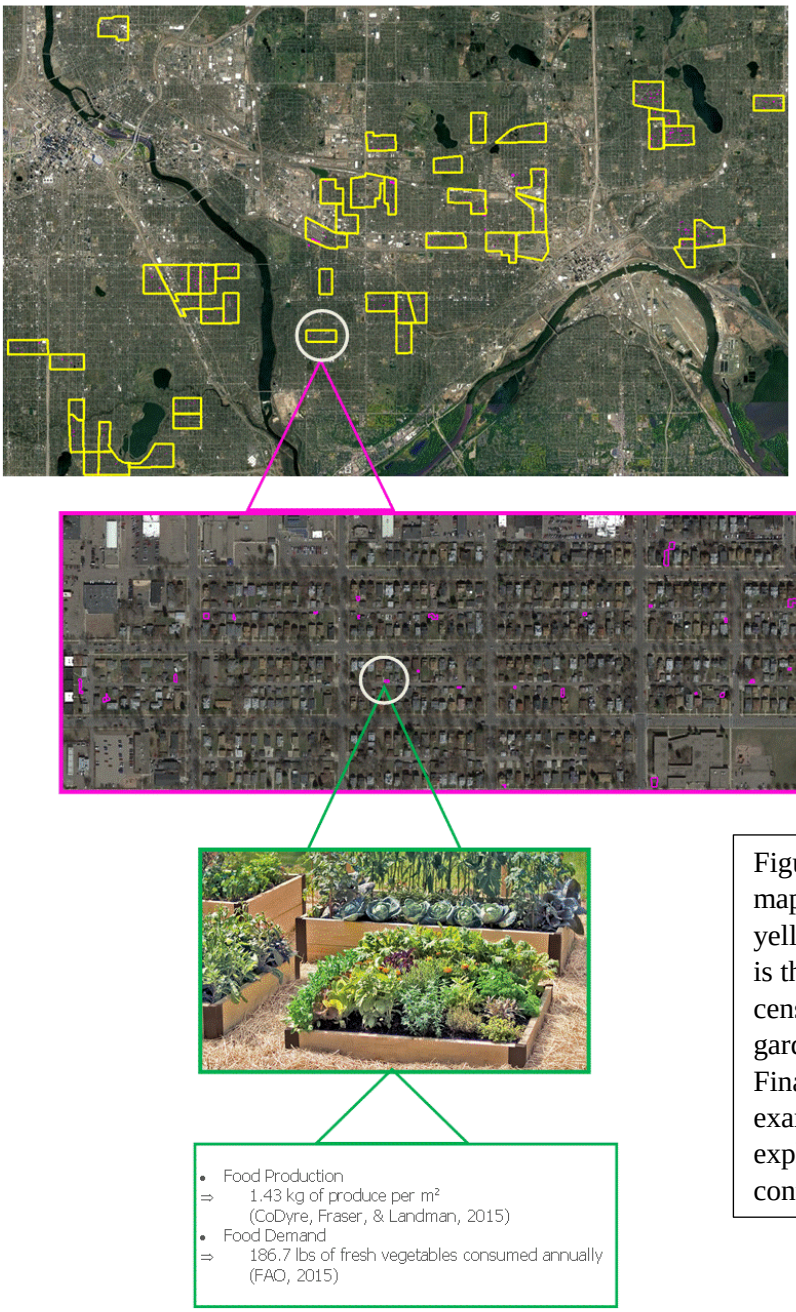


Figure 5 shows the mapped census blocks in yellow. Then, zoomed in is the area within one census block with each garden mapped in pink. Finally, I show an example garden with the explored potential contributions.

2. Methods

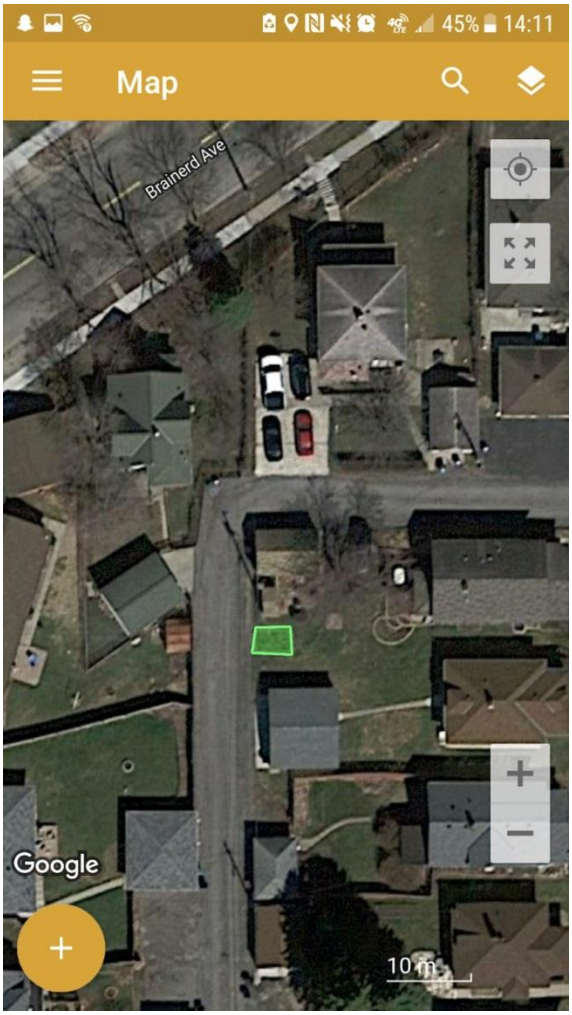
Our objective is to define the current actual contributions of household backyard gardening and community gardening to urban agriculture. I seek to explore the size and distribution of gardens at the census block level by income. To map urban gardening in the Twin Cities, I developed a suitable method

comparing various options that measured the size and distribution of gardens in 36 census blocks. The collected results were used to form an estimate of the frequency and size of urban gardens throughout the Twin Cities. This method is applicable to other locations and could inform city policymakers when considering urban agriculture policy. Furthermore, doubling the amount of gardening in the Twin Cities could increase the percent of the food demand satisfied and other benefits including: carbon storage, water storage, biodiversity, and well-being. Mapping the current urban gardening throughout the Twin Cities has presented a replicable method to explore urban gardening in other locations. This exploration can work toward answering what type of benefits can be expected from small scale gardening – seeking this answer will help inform cities in the extent and form of urban agriculture.

I adopted the Google Earth approach that was developed by (Taylor & Lovell, 2012) and applied to Chicago. This method has later been adapted for the Detroit area as well (Foster and Newell, in preparation), I applied that method here. The method includes ground-truthing (see results for error analysis of the virtual method) which involved finding gardens that had been mapped virtually in the field to assess the virtual mapping. After visually scanning for gardens on Google Earth, ground-truthing the blocks covered, and evaluating the error, it was determined that the Google Earth approach is not suitable for the Twin Cities. Urban density with tall buildings, closely spaced residential plots, and a high concentration of trees and shadows inhibited the applicability of the Google Earth approach in the Twin Cities. While virtual visibility was limited, during our days in the field, I noticed many of the census blocks had alleyways behind the houses. These alleyways improved visibility in the field and resulted in fieldwork that took a comparable amount of time to the virtual approach. Therefore, I developed a transect approach that mimicked ground-truthing while using a smart phone with an app called Fields Area Measure PRO so that identified gardens could be traced, the size and location could be saved, and the measure could be uploaded to Google Earth.

The transect approach involves walking or driving through neighborhoods to visually observe gardens during the growing season. I intentionally selected census blocks that contained alleyways to improve the chances of visibility to observe gardens. While I was in the field I traced gardens using smart phones with an app called "Fields Area Measure PRO." Using this app, I could draw polygons of gardens on our phones that later could be uploaded to Google Earth. Once uploaded, I could obtain the frequency and size of the gardens I had traced in the field. I continually aggregated the measures traced from each day of fieldwork to collect the frequency and size of all mapped census blocks on Google Earth. When there were direct lines of sight into the backyards that made identifying gardens clear, the gardens were mapped if present. When backyards were not visible, I could not include this yard in our mapping. To account for the not visible houses in our study, I determined I needed a way to tell if the number of not visible backyards relative to the garden frequency in a given census block had influenced the reliability of the garden frequency for that block. I decided to tally the number of houses not visible to form an equation that would include the number of not visible houses by considering how the number of not visible backyards changes the overall frequency of gardens in a block.

Figure 6: Fields Area Measure PRO App



To evaluate if I could visibly see enough backyards to gather a representative sample of the total number of gardens in each mapped census block, I included the number of gardens found in the block (G), the frequency of houses with visible gardens (FG), not visible houses (NV), and total households in

the census block area (total) in our equation (see Table 4). This equation allowed me to determine the potential error in the block using estimated error bars. I formed a criterion that each block had to be within 90% of estimated error bars to be used in the study. I evaluated this by setting NV equal to 0.1 and identifying upper and lower bounds of error (step 1 shown in Table 4). Once the upper and lower bounds were defined, I inputted the actual number of not visible houses as NV (step 2 shown in Table 4) and determined whether this value fell within the bounds (step 3 shown in Table 4).

Table 4: Determining the potential error of individual census blocks

#	Description	Equation used
1.	Determining upper and lower bounds	$upper\ bounds\ (UB) = \{(FG) + [(\mathrm{FG}) \times (0.1)]\}$
		$lower\ bounds\ (LB) = \{(\mathrm{FG}) - [(\mathrm{FG}) \times (0.1)]\}$
2.	Test statistic from observed data	$\left\{\frac{\{[(\mathrm{FG}) \times (NV)] + G\}}{total} \times 100\right\}$
3.	Checking bounds with observed data	$\mathrm{LB} < \left\{\frac{\{[(\mathrm{FG}) \times (NV)] + G\}}{total} \times 100\right\} < \mathrm{UB}$

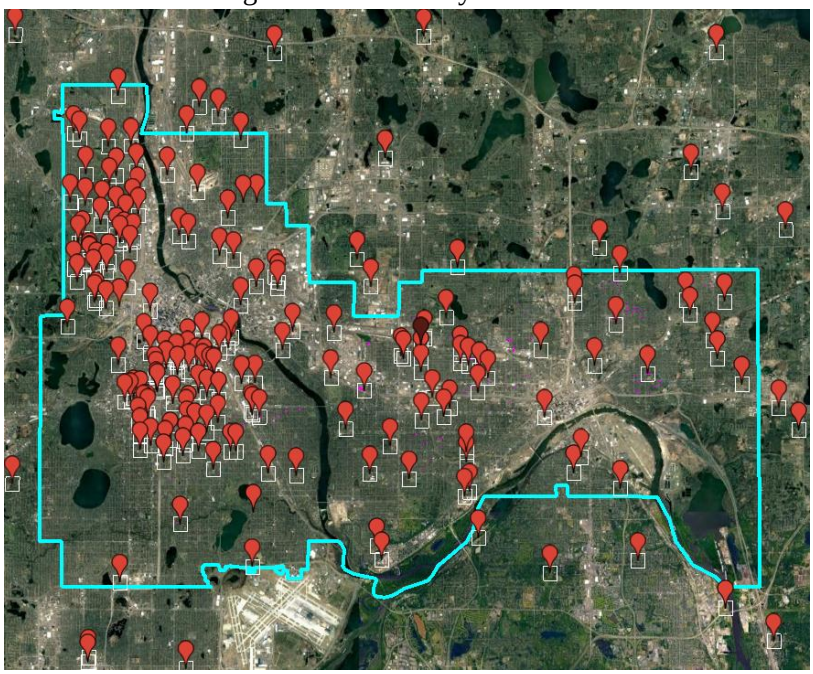
I applied the transect approach to map census blocks within the Twin Cities metro area within a population density of 6,864 to 8,575 including: low, middle, and high incomes at household income levels of $0-$39,999, $40,000-$68,009, and $68,010-$173,617. I assessed the potential of gardens in unexpected areas such as downtown, but I did not locate any gardens.

As I mapped census blocks, I also visually estimated the percent of each garden filled with edible vegetables or noted "unknown" if it was difficult to assess the amount of edible area. Once the garden mapping was complete, I assessed the difference between the frequency and size of gardens at each income block. I tested the difference between the means of the frequency and size of gardens in each of the income groups using a t-test to prove statistically significant difference at the 99% level. I found

significant differences between the low and middle and the low and high income groups for both frequency and size of household gardens. This means I reject the null hypothesis that the means of the income groups are the same and accept the alternative hypothesis that the mean frequency and size of household gardens differs between the low and middle and low and high income groups.

Current local production capacity was assessed using the traced measures by scaling up. This included calculating the frequency gardens at each household in the mapped blocks and using that frequency to predict the number of gardens in census blocks by income level throughout the Twin Cities. I removed the downtown census blocks and any census blocks with a high concentration of apartment buildings and commercial/industrial development without residential housing from the scaling up calculations. After predicting the number of gardens, the median garden area from mapped census blocks was used to predict the garden area throughout the Twin Cities. I used the median garden area due to a high standard deviation in our sample; therefore, I found the median would be more representative than the mean. I also considered the median edible area using the edible area percentages noted during mapping. Using this median edible area, I assessed the yield and percentage of the food demand satisfied. The yield was estimated using 1.43 kg of produce per m^2 of garden area annually (CoDyre, Fraser, & Landman, 2015). Considering the estimated yield, I predicted the amount of food demand satisfied in the Twin Cities using 186.7 pounds of fresh vegetables consumed in 2015 reported by the USDA food availability data (USDA, 2015).

Figure 7: Community Gardens in the Twin Cities



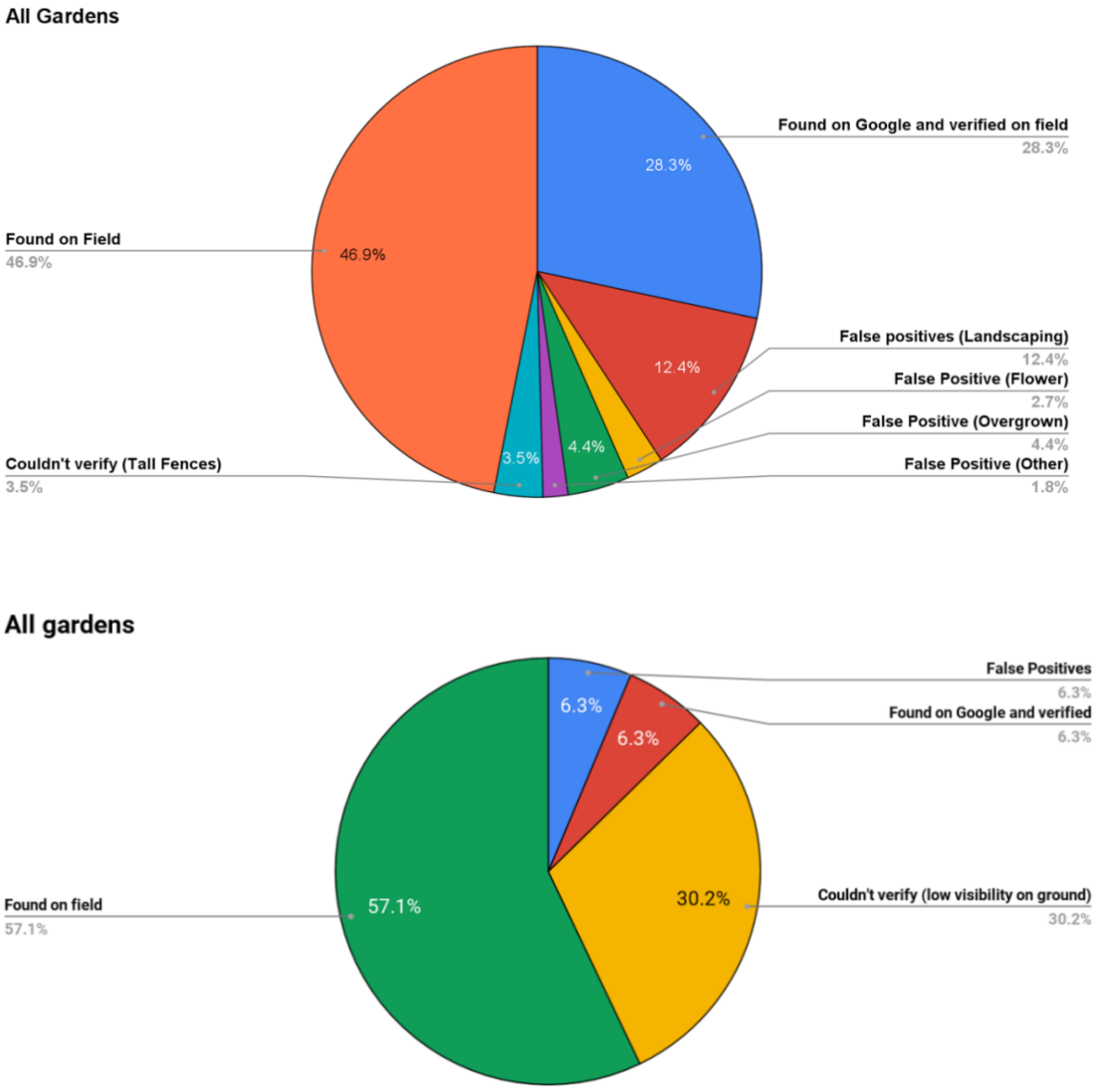
Additionally, I investigated community gardens throughout the

Twin Cities. Homegrown Minneapolis includes a map of community gardens in the Twin Cities metro region. Since the community garden locations are tagged by Gardening Matters (shown in Figure 3), the limitations of the Google Earth approach in the Twin Cities region did not impact mapping the community gardens. Furthermore, community gardens were typically at least 400 m^2 compared to an average garden size of about 20 m^2. Therefore, due to the size and given locations of community gardens, I was able to map these gardens using Google Earth despite the limitations of the Google Earth approach for mapping home gardens. I uploaded the Gardening Matters map (see Figure 3) to Google Earth and then located all community gardens within the Twin Cities limits. When a community garden was present, I drew a polygon of the garden to document the area (shown in Figure 7).

3. Results

After reviewing the applicability of mapping methods in the Twin Cities and ground-truthing the Google Earth method, I found a large amount of error due to visibility issues on Google Earth. I spent two days ground-truthing in the field. The first day ground-truthing results showed 28% accuracy overall. Out of the gardens found on Google Earth, 21% resulted in false positives, meaning these gardens were traced on Google Earth as gardens, but that the gardens were confirmed as not present in the field. Of the total gardens tagged after ground-truthing the census block, 47% were false negatives, meaning that they were not identified on Google Earth, but found in the field. On the second day of ground-truthing, only 6% of all gardens found on Google Earth could be verified. Of all gardens located in the second census block, 57% were false negatives found in the field, 6% false positives, and 30% unverifiable due to low visibility.

Figure 8: Error Analysis



Following the error analysis, I decided to develop a new approach catered to the Twin Cities. Many neighborhoods throughout the Twin Cities have back alleyways, making a transect approach that mapped urban gardens in the field feasible and time-effective.

Using the transect approach, nearly 800 gardens were mapped with almost 20,000 m^2 of gardening area throughout 36 mapped census blocks. I found 180 gardens per census block for low income groups, 270 gardens for middle income, and 330 for high income. This equates to a total of 6,790 m^2 of gardening in low income census blocks, 6,800 m^2 for middle income, and 5,600 m^2 for high income. I found statistical significance in the difference of frequency and size of gardens between income groups. The low-income group showed a lower frequency of gardens, but larger garden size than both middle and high-income groups.

Table 5: Mapping Overview

	Household Gardens			
Income Level	**Census Blocks**	**Households**	**Gardens**	**Garden Area (m^2)**
$0 - $39,999	13	7,266	183	6,790
$40,000 - $68,009	11	4,628	270	6,824
$68,010 - $173,617	12	4,627	333	5,613
Totals	36	16,521	786	19,227

Table 5 shows the number of census blocks, households, gardens, and amount of garden area throughout the mapped area.

Throughout the 786 gardens, sizes varied, generating a high standard deviation in all income groups. Therefore, to consider a representative value for size for scaling up, I looked at the median garden size in each income group. Since the frequency of gardens did not show as high of a standard deviation, I took the average to be representative enough to use for scaling up.

Figure 9: Frequency of Gardening by Income Group

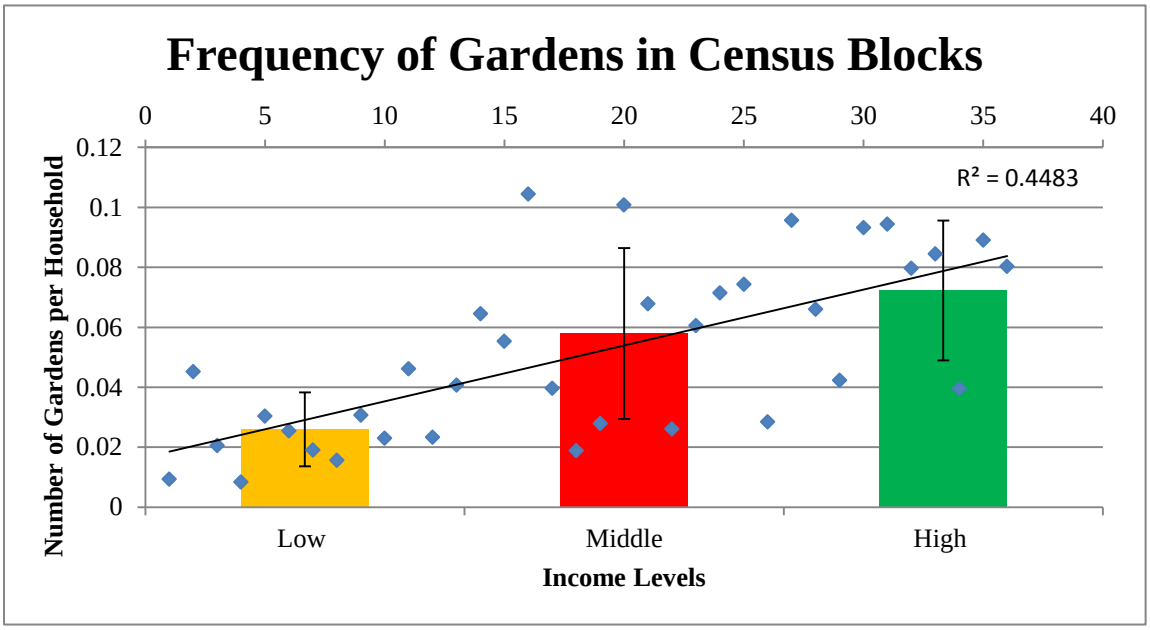


Figure 9 shows the average frequency of gardens by households in each census block across each income level. This frequency was used to scale up and predict the number of gardens in other census blocks throughout the Twin Cities area. The differences betIen low and middle and low and high-income groups are statistically significant at the 99% level. The error bars show the standard deviation.

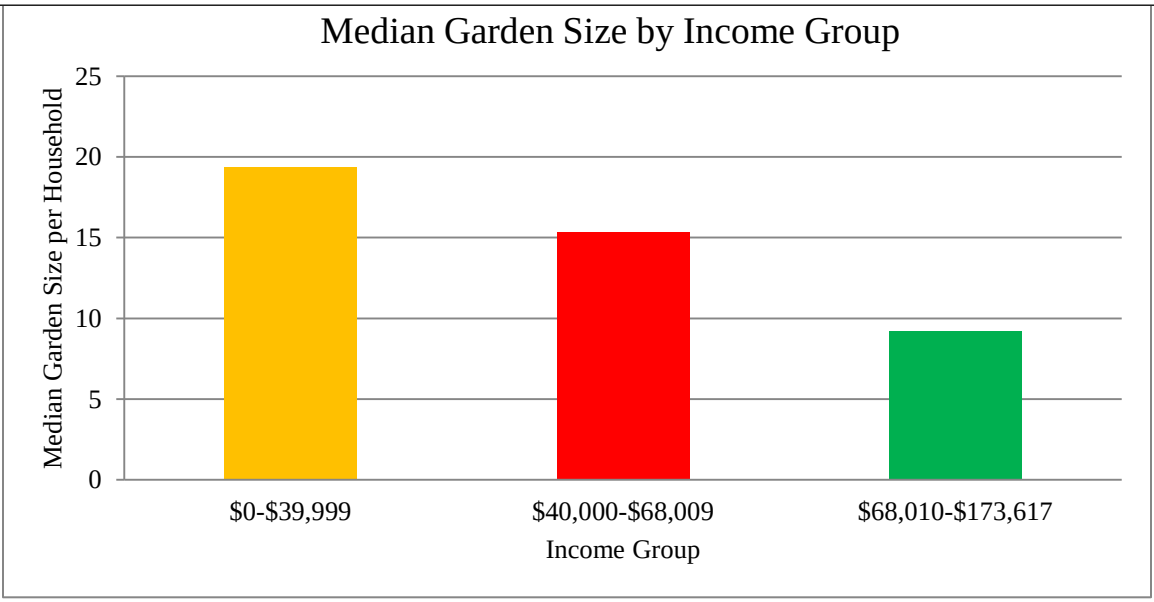


Figure 10 shows the median garden size mapped in census blocks across the three income groups. These numbers were used to predict the size of gardens throughout census blocks in the Twin Cities once the number of gardens was predicted.

After scaling up, this predicts a total of 2,100 gardens in low income groups, 8,360 gardens in middle income, and 5,100 gardens in high income census blocks. These gardens add up to almost 50,000 m^2 of garden area in low income blocks, over 130,000 m^2 in middle income blocks, and over 50,000 m^2 in high income blocks. In total the estimated edible area in gardens could satisfy 0.48% of the food demand in the Twin Cities. Average garden yield was estimated by evaluating the edible area out of the total garden area (on average about 85% to 95% of the total garden area had been tagged as edible) and using 1.43 kg of produce per m^2 of garden per year as a food production estimate (CoDyre et al., 2015). The food demand was assessed using 186.7 pounds of vegetables per capita from USDA data (USDA, 2016).

Table 6: Scaling Up Results

	Household Gardens			
Income Level	**Census Blocks**	**Households**	**Estimated Gardens**	**Estimated Garden Area (m^2)**
$0 - $39,999	179	83,788	2,110	48,906
$40,000 - $68,009	315	143,309	8,361	135,997
$68,110 - $173,617	170	70,878	5,101	53,056
Totals	664	297,975	15,572	237,959

Table 6 shows the predicted number of census blocks, households, gardens, and amount of garden area throughout the Twin Cities.

5.1 Discussion

Our mapping results showed statistical difference between the size and frequency of gardens across income groups. I found fewer household gardens in the low-income group, but larger garden areas. High and middle-income groups show more gardens in total, but smaller gardens. This could suggest that there are barriers to household gardening that limits home gardening in lower income groups.

After identifying and mapping the community gardens marked by Gardening Matters (see Figure 3), I found 66 gardens in low income areas, 54 in middle income, 6 in high income, resulting in 126 total gardens. This amounted to about 55,900 m^2 of gardening area in low income locations, 64,000 m^2 in middle income areas, and 7,300 in m^2 high income locations. On average, the community gardens in low

income areas were about 850 m^2 while community gardens in middle and high income locations were 1180 m^2 and 1215 m^2 respectively.

Table 7: Community Garden Results

Community Gardens				
Income Level	**Gardens**	**Garden Area (m^2)**	**Estimated Yield of Total Garden Area (lbs)**	**Average Garden Size (m^2)**
$0 - $39,999	66	55,900	180,000	850
$40,000 - $68,009	54	64,000	200,000	1,180
$68,010 - $173,617	6	7,300	23,000	1,215
Totals	126	127,000	400,000	1,010

Table 7 shows the number of community gardens total, the total garden area, the estimated yield, and average community garden size throughout the Twin Cities by income level.

After locating and tracing the community gardens from the Gardening Matters map (Figures 3 and 7), I estimated production using the same garden yield estimates for home gardens (CoDyre et al., 2015). Considering population estimates from the American Community Survey provided by the Census Bureau, this would fulfill 0.32% of the food demand in the Twin Cities (Bureau, 2016b).

To test the statistical difference of the community garden size by income level, I use a t-test. Due to high standard deviations in the sizes of community gardens, I found no statistical significance in the t-scores, which means I cannot reject the null hypothesis that the average community garden sizes are different between income levels.

Figure 11: Average Community Garden Size by Income Level

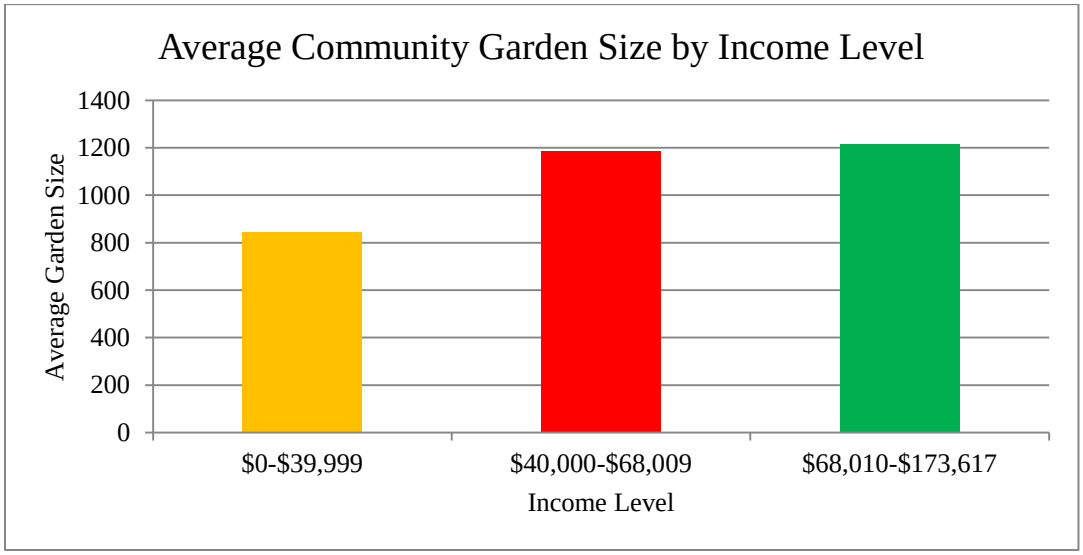


Figure 11 shows the average community garden size found at locations marked by Gardening Matters by income level of locations.

Figure 12 shows the number of community gardens found in each income level when reviewing the Gardening matters map of community gardens (Figures 3 and 7). There were 66 gardens located in low income census blocks, 54 gardens in middle income census blocks, and 6 in high income census blocks.

Figure 12: Number of Community Gardens by Income Level

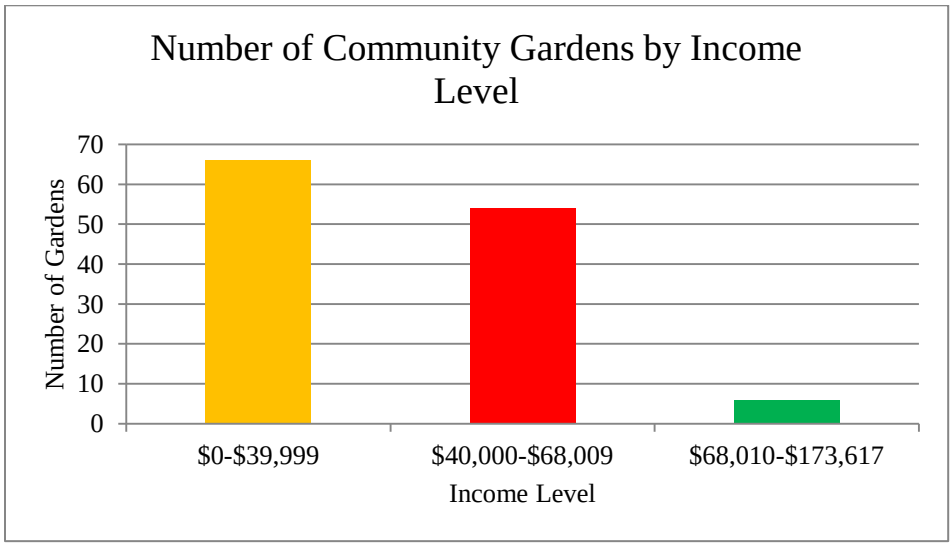


Figure 12 shows the number of community gardens found at the locations marked by Gardening Matters by income level of each location.

4. Implications for Ecosystem Services

Ecosystem services such as carbon storage, water storage, mitigation of the urban heat island effect, and biodiversity are often highly dependent on the size and distribution of the land assumed to be providing these benefits. Since urban agriculture is largely discussed as providing these benefits, it is important to inform the provision of these benefits with actual size and distribution data. With the geospatial dataset formed in this study, further studies measuring ecosystem service benefits can be informed by the size and distribution of urban gardening. Specifically, the size and distribution of urban gardens informed by income level can further inform the equity of ecosystem service benefits to progress environmental justice.

After scaling up, if the urban gardening in the Twin Cities was doubled, 1% of the food demand could be satisfied instead of 0.48%. If ecosystem services findings from the literature were applied to the current estimated garden area throughout the Twin Cities, I would find about 650 tons of carbon stored (with an estimated 20 tons of aboveground carbon storage) and 2.3 million gallons of water stored (Davies et al., 2011; Gittleman, Farmer, Kremer, & McPhearson, 2017; Jo & McPherson, 1995). These combined carbon storage benefits translate to nearly 1.6 million miles driven by an average passenger vehicle (using 8.8 kg CO2/gallon and 21.6 mpg) and enough water to fill 3 and a half Olympic sized swimming pools (U.S. EPA, 2014).

If urban gardening was doubled, I would see over 1300 tons of carbon storage (40 tons of aboveground carbon storage) and 4.5 million gallons of water storage (Davies et al., 2011; Gittleman et al., 2017; Jo & McPherson, 1995). This increases the carbon equivalencies to 3.2 million miles driven by an average passenger vehicle and is now enough water to fill almost 7 Olympic sized swimming pools (US EPA, OAR,OAP, 2017). Furthermore, an increase in urban gardening will increase biodiversity in the city (Cameron et al., 2012; Goddard et al., 2010; Strohbach et al., 2013). A study conducted within our research group reveals that the garden area mapped in this study is likely too distributed with small

individual plots to result in urban heat island mitigation benefits (Habeeb, in preparation). Currently, our research group is pursuing a study to ask the question of exactly how the size and distribution of urban agriculture impacts urban heat island mitigation benefits.

There are flaws to estimating ecosystem services using findings supported by literature. The amount of carbon stored in the five different carbon pools (aboveground biomass, belowground biomass, deadwood, litter, and soil organic carbon) is not geospatially consistent. To be specific to the Twin Cities region, the carbon pools in this area would have to be examined. The Natural Capital project has developed models that perform these analyses once supplied with datasets, including InVEST. Similarly, water storage is regionally inconsistent and varies by crops due to the make-up of the root systems. Other tradeoffs with considering stormwater runoff benefits of urban gardens are water quality issues. One study on stormwater runoff in urban agriculture sites in the Twin Cities found that while the runoff can be reduced by around 80%, the quality of that water is severely impacted by the fertilizers used in most gardens (Hankard et al., 2016). When considering biodiversity, the benefits vary based on how it is measured. Several studies use species richness in birds as an indicator of biodiversity (Goddard et al., 2010; Strohbach et al., 2013). However, this fails to inform different scales of biodiversity such as insects, soil, and other forms of wildlife. Other studies discuss landscape heterogeneity and measure biodiversity by varying landscapes in urban environments (Baró, Haase, Gómez-Baggethun, & Frantzeskaki, 2015; Meerow & NeIll, 2017). Landscape heterogeneity more likely benefits human Ill-being, recreation, and stress relief than actual ecosystem biodiversity.

The seasonality and purpose of urban gardens can limit ecosystem service benefits. This study focused on vegetable gardens to quantify food production and consider the food supply contributions. Vegetable gardens are harvested each season and therefore are often barren in the off season. When these gardens are barren, they lose nearly all ecosystem service benefits. The carbon storage of root systems and aboveground vegetation would be lost, and the water storage capacity would be reduced due to the lack of root systems. Due to these seasonal inconsistencies, vegetable gardens may be net zero in carbon

storage as a result of harvests. Furthermore, stormwater runoff may be exacerbated when these gardens are barren with increased soil erosion. Garden management techniques vary and have high impacts on all of the ecosystem service benefits discussed.

4.1 Implications for Policy

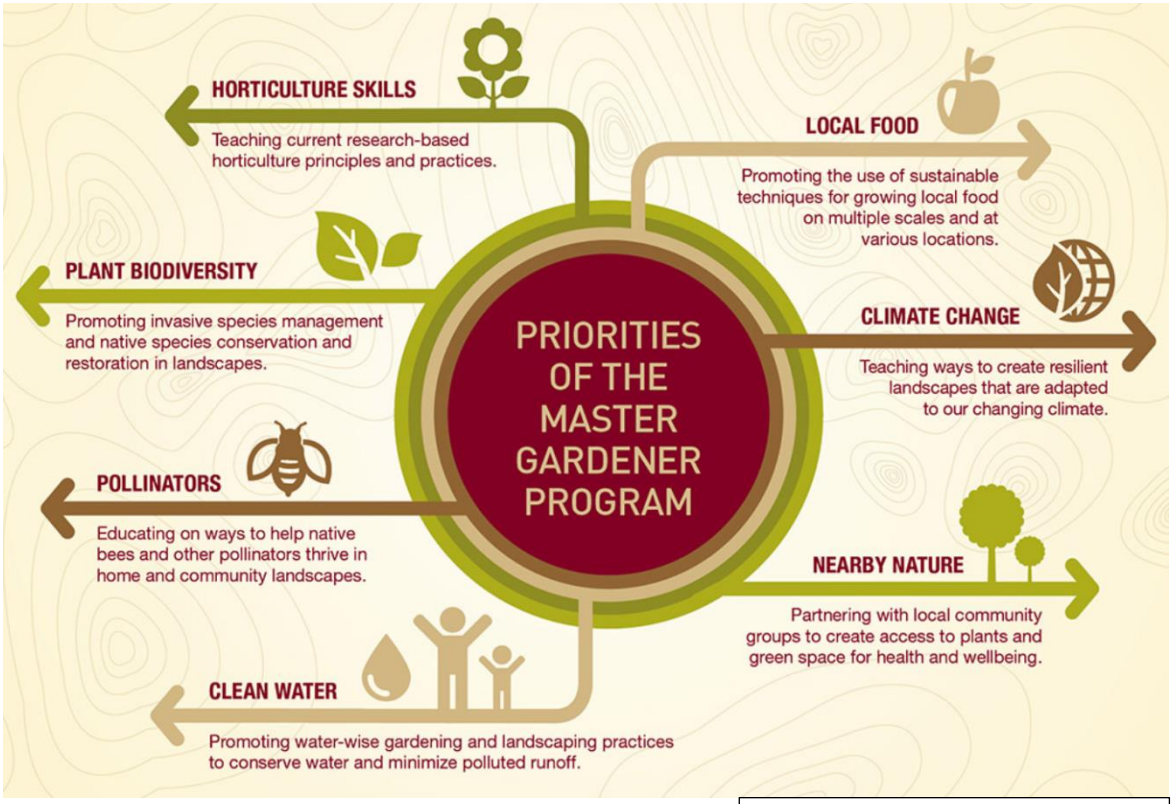
This paper is important for city-level policymakers to understand the current state of urban agriculture. This paper is specific to the Twin Cities; therefore Homegrown Minneapolis would be one of the main target audiences. However, this study design could be replicated to other cities to inform other city-level policymakers of the current state of urban agriculture contributions from home and community gardens to inform specific urban food policy. Food policy in cities is still a developing field. While international initiatives such as the Milan-Urban Food Policy Pact, the New Urban Agenda, and the Sustainable Development Goals all inform food policy in various ways, city policymakers are still in the process of interpreting these initiatives to city-level policies. As highlighted in Table 2 and detailed in Appendix 2, often cities are interpreting food initiatives to broadly promote urban agriculture for a wide variety of perceived benefits. This study helps inform what out of those benefits may be feasible for urban agriculture and what benefits are out of reach for current urban agriculture in the Twin Cities.

I found a statistically significant difference between size and frequency of household gardens by income group. The low-income group tended to have fewer gardens while they were larger and middle and high-income groups tended to have more gardens, but they were smaller. This trend could inform ways to promote urban gardening and to support gardening initiatives targeted to specific income levels. To support gardening in the low-income group, gardening programs should work on land acquisition to plan for large gardening sites. If policy seeks to increase the amount of garden space in the middle or high-income groups, our study findings suggest this may be achieved by encouraging more gardens rather than promoting an increase in individual garden size.

Out of the total community gardens tagged on Gardening Matters, 71% were found on Google Earth. Maintaining current community gardens should be promoted in urban agriculture policy. It is important to both maintain the physical resources of existing community gardens and to maintain the virtual resources encouraging access to community gardens. Community residents should have access to up-to-date information about community garden resources. Therefore, it is recommended that the Gardening Matters dataset be cleaned to represent the community gardens present.

Garden management education is a vital part of garden success. The yields, soil health, water use, pesticide and herbicide use, and pollinator benefits all depend on proper garden management. To promote healthy garden management, the University of Minnesota Extension offers a master gardener program. A diagram of the program's main topics is shown in Figure 12. Master gardeners learn about local food, climate change, horticulture, pollinators, plant diversity, clean water, and nearby nature (University of Minnesota, 2018a). Both Hennepin and Ramsey Counties promote the Master Gardener Program on their website. The program requires 50 hours of volunteer work to be completed in the first year and 25 hours completed in each year thereafter to remain active (University of Minnesota, 2018b). The volunteering time requirement is good because it encourages participants to volunteer and creates time to learn the techniques necessary for good garden management. However, this volunteering time requirement may be infeasible for low income households. Especially if these low income households are also low mobility. Therefore, to impact gardening where it is most needed for individual food security and nutrition, master gardeners should volunteer expertise in community gardens in low income neighborhoods. Homegrown Minneapolis could assist by identifying the community garden locations in most need using the mapped dataset from Gardening Matters (see Figures 3 and 7) and the Healthy Food Access Map (see Figure 2).

Figure 13: Master Gardener Program Outline



(University of Minnesota, 2018)

Urban agriculture should be promoted for the right reasons. Our study reveals that urban agriculture cannot provide local self-sufficiency for the Twin Cities. However, gardens can provide household nutrition and improve household food security. Urban agriculture is celebrated as a contributor to economic development, education, healthy food access, equitable food access, food security, and nutrition. Current urban food policies (see Appendix 2) support these benefits in all forms of urban agriculture. This study provides an understanding that urban gardening is currently limited in supplying all these benefits but reveals that it can be a tool for some of the benefits including nutrition and household food security.

Our findings are relevant to Minneapolis specifically because Minneapolis includes urban agriculture in two of its main food policy objectives. Minneapolis has explored urban agriculture as a means for healthy food access and has added focus on income inequality in healthy food access by

tracking low income and low vehicle access areas on the healthy food access map (Figure 2). Therefore, finding more community gardens in low income areas and less home gardens can provide insight to the types of policies the city should pursue to promote equal access to healthy food through gardening. These findings also inform some current policies the city has formed to promote urban agriculture including the Garden Lease Program and the Garden Compost Program (City of Minneapolis, 2018b, 2018a). Currently, these programs seek to make procuring land for community gardens and resources to maintain the gardens more accessible. Ensuring that residents are aware and able to take advantage of these existing policies is another important consideration for the city.

Furthermore, the mapping method presented in this paper can be replicated to other areas to understand the size and distribution of gardens in other cities. Evaluating the size and distribution of gardens in other cities allows these cities to make urban agriculture policy recommendations based on an understanding of current urban agriculture. The dataset created by this study presents opportunities for further studies. The size and distribution of gardens could be used in further ecosystem services studies, but also could be used in a finer scale understanding of garden capabilities. For example, does the city interact with and support individual community gardens? Do the communities supporting these gardens have the necessary resources, access to existing lines of assistance, or education to partake in policies? The information gathered in this study documenting the current stated benefits in urban food policies, the current size and distribution of urban gardens, and how this size and distribution varies between income levels opens doors to answering these questions. For example, I found multiple objectives and strategies for urban agriculture, which can inform urban food policy on issues with inconsistencies between scales and unsupported statements. The information on the current size and distribution reveals several important insights including the amount that urban gardens could potentially contribute to satisfying food demand and the location of gardeners for future studies. The differences between income levels shows that urban gardening is not consistent between low, middle, and high income levels and this may inform specific policy on success of equity goals in urban agriculture.

5. Conclusions – Will Doubling Urban Agriculture Improve Self-Reliance?

Urban gardening is promoted as a valuable component of the food system because it provides household nutrition and improves home food security. Furthermore, urban gardening is believed to have strong positive Ill-being contributions including: stress relief, recreation and improved overall health (Cameron et al., 2012; Kortright & Wakefield, 2011; Lovell & Taylor, 2013; Tzoulas et al., 2007). Urban garden yields could be greatly improved with educational programs and resources for improving the growing conditions of the garden (maintaining soil health, proper fertilizer application, etc.). In the Twin Cities, Homegrown Minneapolis works to support the urban food system for city residents. As mentioned above, Homegrown hosts a community garden lease program that allows residents to lease vacant plots for community gardens and a composting program that provides compost for gardens at reduced prices or even free if needed. The garden lease program also exists for those who want to turn vacant lots into market gardens or commercial urban farms. These resources are essential for urban gardeners to flourish, especially for improving the accessibility of urban gardening. Further educational opportunities to teach garden management could help improve food production and ecosystem service benefits of gardens. The type of garden management largely impacts the productivity of the garden. CoDyre et al, where I obtained garden yield estimates, reported high variability in the individual garden yields based on how the gardens were managed (CoDyre et al., 2015). Therefore, training individual gardens and educating those involved in community gardening could improve yields significantly. These initiatives are important ways to contribute to household food security and wellbeing, but our findings suggest that doubling urban agriculture in the Twin Cities would not contribute to food self-reliance.

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2013)(Liebman, Jonasson, & Wiese, 2011; Meerow & NeIll, 2017)(Parece et al., 2017)(Hankard et al.,

2016)

Garden image: 2018 Gardener's Supply Company, 128 Intervale Road, Burlington, VT 05401

AMERICA'S GARDENING RESOURCE

FAO fresh veg demand 2015: 172.

Appendix 1: SDG Linkages to Urban Agriculture

SDG		Description	Connection to Local Food Supply
1	No poverty	End poverty in all its forms everywhere	Urban agriculture to alleviate poverty
2	Zero hunger	End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Urban agriculture to promote food security
3	Good health and Ill-being	Ensure healthy lives and promote Ill-being for all at all ages	Urban agriculture provides health and Ill-being benefits
5	Gender equality	Achieve gender equality and empower all women and girls	Improve food security; relieve the burden of acquiring food.
6	Clean water and sanitation	Ensure availability and sustainable management of water and sanitation for all	Stormwater runoff mitigation in urban agriculture
8	Decent work and economic growth	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Urban agriculture to generate local economic development.
9	Industry, innovation and infrastructure	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	Urban agriculture to provide equitable food access and resilient infrastructure.
10	Reduced inequalities	Reduce inequality within and among countries	Urban agriculture to provide equitable food access.
11	Sustainable cities and communities	Make cities and human settlements inclusive, safe, resilient and sustainable	Local food provision in cities to improve sustainability.
12	Responsible consumption and production	Ensure sustainable consumption and production patterns	Local food production and consumption considered more sustainable.
13	Climate action	Take urgent action to combat climate change and its impacts	Urban agriculture to mitigate urban heat island effect. Reduced food transportation miles.
15	Life on land	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Urban agriculture as sustainable land use, to reverse land degradation, and to improve biodiversity.

Appendix 2: Urban Food Policies

City	Policy	Objectives	Strategies
Austin* (Athens & Marty, 2016)	Austin Healthy Food Access Initiative	Increase food security	Increase urban food production
		Improve healthy food access	Pilot a nutritious food incentive program, expand healthy food retail initiatives, complete a food environment analysis
		Nutrition education	Develop a coordinated awareness campaign about nutritious food resources
Baltimore* (Homegrown Baltimore, 2013)	Homegrown Baltimore: Grow Local	Increase healthy food access	Build community's food self-reliance through increased local food supply
		Develop local economy and create jobs	Job creation with new employment sector opportunities
		Improve the natural environment	Composting, reducing packaging waste, reduce storm water runoff, reduce air pollution, climate regulation, increase biodiversity
		Contribute to environmental sustainability	Decrease food miles, decrease food waste, reduce energy use and GHG emissions, carbon sequestration
		Strengthen community resilience	Re-localizes food system and create community bonds
		Education opportunities in food system	Use urban agriculture sites as information hubs
Chicago* (Rahm Emanuel et al., 2013)	Chicago Food Plan	Build healthier neighborhoods	Gather data on obesity-related health disparities.
		Grow food	Support urban food production
		Expand healthy food enterprises	Increase healthy food retail
		Strengthen the food safety net	Increase food assistance programs
		Serve healthy food and beverages	Increase free drinking water access and healthy food choices
		Improve eating habits	Increase nutrition education
Cleveland (Maskin et al., 2014)	Regional Food Policy Council Report	Agriculture	Assess agricultural activity
		Economic development	Convene on economic functions
		Education	Promote educational programs
		Environment	Advocate and communicate environmental issues
		Equity	Share information and promote healthy food access and education
		Health	Form policy supporting healthy food
		Policy	Improve leverage across sectors
Detroit (Arellano Stephen & Kuras Amy, 2017)	Creating a Food Secure Detroit: Policy Review and Update	Access to quality food	Support urban agriculture
		Hunger and malnutrition	Support urban agriculture and nutrition assistance
		Impacts/effects of poor diet	Track and monitor
		Citizen education	Promote educational programs
		Economic injustice in the food system	Promote equal land use access
		Urban agriculture	Promote land access
		Governance and education	Educational growing
		Emergency response	Develop adequate food and water reserves
Madison*	Currently working on a comprehensive plan		

Minneapolis* (Minneapolis, 2011)	Urban Agriculture Policy Plan	Promote and support a local food system	Supporting and promoting community gardening, farmers' markets, commercial urban agriculture, and small enterprise or value-added agriculture in all city neighborhoods
		Land availability for urban agriculture	Complete land capacity analysis and track vacant land and land demand
		Equal access for growing and fresh food	Identify growing opportunities and increase transit access to healthy food
		Economic opportunity	Encourage food business development
		Innovative design for food growing	Use policies and incentives to encourage developers to include space for food production and distribution and composting
		Encourage ecological sustainability	Track and improve soil health
		Biodiversity	Understand animal role in local food system
New Orleans (New Orleans Food Policy Council, 2017)	New Orleans Food Policy Advisory Committee Strategic Plan	Food-related business development	Hire food policy coordinator
		Food access and education	Literature review
		Food production	Research best practices locally, regionally, and nationally
		Collaboration	Develop partnerships with policy-makers, New Orleans community, institutions, non-profits, businesses and civic groups
New York City* (City of New York, 2017)	NYC Food Policy	Address food insecurity in New York City	Food Assistance Collaborative
		Improve city food procurement and service	Target public facilities and improve healthy food access in these facilities
		Increase healthy food access	Nutrition education, expanding food purchasing support programs, and expanding healthy food supplied in retail
		Support a just and sustainable food system	Increase urban food production, improve education
Philadelphia (Philadelphia Food Policy Council, 2017)	Philadelphia Food Policy Report	Reduce hunger	Create website to find healthy food options
		Improve healthy food access	Improve quality of food in public facilities
		Good food procurement	Create guides on healthy food catering
		Urban agriculture	Procure land for urban agriculture, gather data on urban gardens
		Economic development	Workforce trainings
		Support zero waste	Install compost facilities, collaborate with zero waste and litter cabinet
		Support food system governance	Make food system participation accessible
Pittsburgh* (Pittsburgh Food Policy Council, 2017)	Pittsburgh Food Policy Council Working Groups	Food and health equity	Develop policies to improve access and affordability of fresh healthy food
		Food access initiatives	Improve access to fresh, healthy, local foods in low-income neighborhoods
		Urban agriculture	Procure land for urban growing
		Regional food economy	Increase opportunities for local food procurement while ensuring equity
Portland (City of Portland &	Portland Multnomah Food Policy	Urban agriculture	Promote community gardens and local food production through farmers' markets, market gardens, and food distribution points
		Healthy food access	Health retail initiative

Multnomah County, 2011)	Council	Food justice	Listen to community experiences and priorities for food justice
San Francisco* (Sokolove & Chen, 2014)	Food System Policy Program	Equitable, affordable, and accessible	Urban agriculture and land access
		Health promoting	Nutrition education programs
		Community building	Community gardens
		Environmentally conscious	Promote local production
		Economically balanced	Encourage job development through urban agriculture
		Sustainable and resilient	Promote urban agriculture
		Transparent and safe	Communicate through the food policy council
Seattle (Lerman, 2012)	Seattle Food Action Plan	Healthy food for all	Promote local, affordable, healthy food
		Grow local	Promote urban agriculture
		Strengthen the local economy	Support farmers' markets and local growers
		Prevent food waste	Compost and prevent edible food from entering the waste stream
Washington DC* (District of Columbia Food Policy Council, 2017)	DC Food Policy Council Report	Food equity, access, and health and nutrition education	Policies and programs to encourage healthy food access
		Urban agriculture, food system education	Remove unnecessary regulations inhibiting urban agriculture
		Local food business and labor development	Gather data on the food economy
		Sustainable food procurement	Support sustainable food purchasing
West Sacramento* (Cutler & Mueller, 2015)	Food System Action Plan	Ensure the viability of food and agriculture economy at all scales	Increase financing and land access for growers
		Increase the amount of locally-grown food	Establish regional food hubs and implement food procurement strategy
		Increase equal access to heathy food	Strengthen food assistance
		Increase food and nutrition education	Develop food education programs

Appendix 3: Milan-Urban Food Policy Pact

MUFFP Framework of Action - Work stream/ Aim	Impact Areas	Recommended Actions
Ensuring an enabling environment for effective action (governance)	Participatory food governance structures exist and are cross-jurisdictional, cross-sectorial and multi-stakeholder	Facilitate collaboration across city agencies and departments and seek alignment of policies and programmes that impact the food system across multiple sectors and administrative levels.
	Participatory food governance structures enhance transparency, ownership, collaboration and co-investment among multiple stakeholders	Enhance stakeholder participation at the city level through political dialogue, as Ill as through education and awareness raising.
	Urban food system policies, legislation, and strategies exist and are integrated into other policies, planning processes and programmes	Develop or revise urban food policies and plans and ensure allocation of appropriate resources within city administration.
	Knowledge sharing mechanisms are developed and used for food policy development and accountability by enhancing the availability, quality, quantity, coverage and management and exchange of data related to urban food systems, including both formal data collection and data generated by civil society and other partners	Identify, map and evaluate local initiatives and civil society food movements in order to transform best practices into relevant programmes and policies. Develop or improve multisectoral information systems for policy development and accountability.
	The food system is being included in city disaster and resilience assessments and response plans	Develop a disaster risk reduction strategy to enhance the resilience of urban food systems.
Sustainable diets and nutrition	Urban residents have access to affordable, sufficient, nutritious, safe, adequate, and diversified food that contribute to healthy diets and meet dietary needs	Promote sustainable diets.
	Decrease in prevalence of non-communicable diseases and improved status of diet-related physical and mental health in specific communities	Address non-communicable diseases associated with poor diets and obesity.
	Food, health and educational policies addresses and improves sustainable diets and nutrition and coordinates action between health and food sectors	Develop sustainable dietary guidelines. Explore regulatory and voluntary instruments to promote sustainable diets. Encourage joint action by health and food sectors. A) Adapt standards and regulations to make sustainable diets accessible in public and private sector facilities.
	All residents have access to safe	B) Adapt standards and regulations to make d safe

	drinking water and sanitation	drinking water accessible in public and private sector facilities. Invest in and commit to achieving universal access to safe drinking water and adequate sanitation.
Social and economic equity	Increase in level of food security for specific vulnerable groups	Use cash and food transfers, and other forms of social protection systems to provide vulnerable populations with access to healthy food Reorient school feeding programmes and other institutional food service to provide healthy and local/regional food.
	Fair and decent (formal and informal) jobs and income opportunities exist for small-scale producers, workers (including youth and women) and businesses throughout the food system	Promote decent employment for all, within the food and agriculture sector, with the full inclusion of women. Encourage and support social and solidarity economy activities, that support sustainable livelihoods in the food chain and facilitate access to safe and healthy foods
	Food policies address and improve social inclusion	Promote networks and support grassroots activities that create social inclusion and provide food to marginalized individuals.
	Local communities are equipped with knowledge, skills and expertise to develop local food system activities	Promote participatory education, training and research in strengthening local food system action.
Food production	Urban and peri-urban food production and processing capacity is optimised and lessen dependence on distant food supply sources	Promote and strengthen urban and peri-urban food production and processing
	Urban planners protect the local agricultural resource base and use in land use and city development plans	Protect and enable secure access and tenure to land for sustainable food production in urban and peri-urban areas Apply an ecosystem approach to guide holistic and integrated land use planning and management.
	Producers have the required knowledge, skills and expertise	Help provide services to food producers in and around cities.
	Efficient and diverse agricultural supply and value chains connect the city with food producers in the peri-urban and surrounding rural area providing access to a wide range of market opportunities	Seek coherence between the city and nearby rural food production, processing and distribution. Support short food chains, producer organisations, producer-to-consumer networks and platforms.
	Strengthen connection between urban and rural areas through recycling and reuse of organic waste, water and energy	Improve (waste) water management and reuse in agriculture and food production.
Food supply and distribution	Food flow assessment is done and increases understanding of possible impacts resulting from targeted improvements in the food chain	Assess the flows of food to and through cities.

	Local food processing, storage and distribution capacity is improved and optimised	Support improved food storage, processing, transport and distribution technologies and infrastructure linking peri-urban and near rural areas.
	Food market functioning and infrastructure is improved and optimised	Provide policy and programme support for municipal public food markets. Improve and expand support for infrastructure related to food market systems.
	Public procurement and trade policies facilitate local and sustainable food supply and distribution	Review public procurement and trade policy aimed at facilitating food supply from short chains.
	Food processing, retail and catering sectors comply with sanitation and food safety regulations	Assess, review and/or strengthen food control systems.
	Food policy and programmes recognise and support the role of the informal food sector	Acknowledge the informal sector's contribution to urban food systems.
Food waste	Food loss and waste is reduced (or re-used) throughout the food system	Convene food system actors to assess and monitor food loss and waste reduction at all stages of the city region food supply chain. Raise awareness of food loss and waste through targeted events and campaigns.
	Food loss and waste policies and regulations are developed and supported by a broad range of stakeholders	Collaborate with the private sector along with research, educational and community-based organisations to develop and review, municipal policies and regulations to prevent waste or safely recover food.
	Increase in the volume of safe food recovered and distributed for human consumption	Save food by facilitating recovery and redistribution for human consumption.

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